What is the optimal proportion of dietary fat, CHO and protein to lose weight if overweight or obese?

Conclusion

There is strong and consistent evidence that when calorie intake is controlled, macronutrient proportion of the diet is not related to losing weight.

Grade: Strong

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades, click here.

Evidence Summary Overview

This conclusion is based on 36 articles published since 2004: Five review articles, 31 randomized controlled trials (RCTs), and one non-randomized controlled trial (Arvidsson, 2004; Avenell, 2004; Benassi-Evans, 2009; Bopp, 2008; Buscemi, 2009; Capel, 2008; de Luis, 2009; Frisch, 2009; Gordon, 2008; Halton, 2004; Halyburton, 2007; Hession, 2009; Jenkins, 2009; Johnston, 2006; Johnstone, 2008; Keogh, 2008; Krieger, 2006; Leidy, 2007; Lim, 2009; Lopez-Fontana, 2009; Mahon, 2007; McAuley, 2005; McLaughlin, 2006; McMillan-Price, 2006; Miller, 2009; Nickols-Richardson, 2005; Noakes, 2006; Nordmann, 2006; Rankin, 2007; Sacks, 2009; Shai, 2008; Tay, 2008; Viguerie, 2005; Volek, 2009; Wal, 2007; White, 2007). Studies were conducted in Australia, Canada, Germany, Israel, New Zealand, Spain, Sweden, the United Kingdom (UK) and the United States (US). The active weight loss phase in these studies ranged from two weeks to six months, with weight maintenance assessed through 24 months. Studies also ranged in sample size from 17 to 645 subjects, and had dropout rates from 0% to 34%. Diets tested ranged from 26% to 66% energy from fat, 15% to 50% energy from protein (PRO) and 4% to 54% energy from carbohydrate (CHO).

Twenty studies found no difference in weight loss between diets differing in macronutrient proportion (Arvidsson, 2004; Avenell, 2004; Benassi-Evans, 2009; Capel, 2008; de Luis, 2009; Frisch, 2009; Gordon, 2008; Jenkins, 2009; Johnston, 2006; Leidy, 2007; Lim, 2009; Lopez-Fontana, 2009; McLaughlin, 2006; Miller, 2009; Noakes, 2006; Sacks, 2009; Tay, 2008; Viguerie, 2005; Wal, 2007; White, 2007).

Thirteen studies found that lower CHO diets reduced weight significantly more than low-fat or higher-CHO diets (Buscemi, 2009; Halyburton, 2007; Hession, 2009; Johnstone, 2008; Keogh, 2008; Krieger, 2006; Mahon, 2007; McAuley, 2005; Nickols-Richardson, 2005; Nordmann, 2006; Rankin, 2007; Shai, 2008; Volek, 2009).

Four studies found that higher-PRO diets reduced weight significantly more than lower-PRO or higher-CHO diets (Bopp, 2008; Halton, 2004; Mahon, 2007; McMillan-Price, 2006). One study found a diet higher in PRO from chicken, but not beef, to be more effective than a lower-PRO diet for weight loss (Mahon, 2007). One study found higher-PRO diets to be more effective than lower-PRO diets for short-term weight loss, but the evidence for effectiveness of higher-PRO diets for long-term weight loss was inconclusive (Halton, 2004).

Evidence Summary Paragraphs (36)

Systematic Reviews and Meta-analyses (5)

Avenell et al, 2004 (positive quality) systematically reviewed RCTs published in the US and Europe to compare the effectiveness of various diets with at least one year of follow-up. The final sample included 26 RCTs that compared low-fat diets (LFD; advice given to reduce fat, more than 6.7 mJ per day), low-calorie diets (LCD, 4.2 to 6.7mJ per day) or very-low-calorie diets (VLCD, less than 4.2mJ per day) with control treatment, or compared to other types of diets, as well as protein-sparing modified fasts (PSMF; 40 g or less a day of CHO) with LCDs and VLCDS. Low-fat diets produced significant weight losses up to 36 months (-3.55kg, 95% CI: -4.54 to -2.55kg). Very-low-calorie diets were associated with the most weight loss after 12 months (-13.40kg, 95% CI: -18.43 to -8.37kg) in one small study. There was no evidence that PSMFs were associated with greater long-term weight loss than LCDs or VLCDs.

Halton et al, 2004 (positive quality) systematically reviewed the body of literature on high-PRO diets to investigate the effects of high- and low-PRO diets on dietary thermogenesis, satiety, body weight and fat loss. The authors included 50 articles in their review that compare a relatively higher-PRO diet with a relatively lower-PRO diet. Results of the review showed that there is strong evidence that higher-PRO intake increases dietary thermogenesis and satiety compared to diets of lower-PRO content, and that high-PRO meals lead to reductions in subsequent energy intake. However, while some evidence suggests that higher-PRO diets result in increased weight loss and fat loss compared to lower-PRO diets in the short term (within six months), findings are inconsistent.

Hession et al, 2009 (positive quality) performed a systematic review and meta-analysis to assess the weight-loss effects of low-carbohydrate diets compared with low-fat/low-calorie diets. Randomized controlled trials conducted in adults with a body mass index (BMI) 28kg/m^2 or higher that lasted for more than six months were included in the review. In addition, low-CHO diets were defined as "less than 60g per day of CHO" and low-fat/low-calorie diets were defined as "less than 30% energy from fat, and -600kcal deficit diet." At six months, weight change was -4.02kg in favor of the low-CHO diets compared to the low-fat/low-calorie diets (P<0.0001) and by 12 months, this difference was still significant at -1.05kg (P<0.05). There was also a higher attrition rate in the low-calorie/low-fat diets than the low-CHO diets.

Krieger et al, 2006 (positive quality) performed a meta-analysis (meta-regression) to determine whether low-CHO, high-PRO weight-loss diets benefit body mass and composition beyond energy restriction alone. The final sample included 87 studies involving a dietary intervention that were published between 1950 and 2005, had subjects older than 19 years of age, and involved pre- and post-dietary measurements of body mass or body composition. Studies that used self-reported dietary intake were required to have a biological marker measurement as an objective measure of compliance. After controlling for energy intake, diets consisting of less than 35% to 41.4% of energy from CHO were associated with a 1.74 kg greater loss of body mass, a 0.69kg greater loss of fat-free mass, a 1.29% greater loss in percentage body fat, and a 2.05kg greater loss of fat mass than were diets with a higher percentage of energy from CHO. In studies that were conducted for more than 12 weeks, these differences increased to a 6.56kg greater loss of body mass, a 1.74kg greater loss of fat-free mass, a 3.55% greater loss in percentage body fat and a 5.57kg greater loss of fat mass. Protein intakes of more than 1.05g per kg were associated with 0.60kg additional fat-free mass retention compared with diets with protein intakes 1.05g per kg or more. In studies that were conducted for more than 12 weeks, higher PRO intakes were associated with 1.21kg additional fat-free mass retention. However, no significant (NS) effects of PRO intake on loss of either body mass or fat mass were observed.

Nordmann et al, 2006 (positive quality) performed a meta-analysis to compare the effects of low-CHO diets without energy restriction to energy-restricted low-fat diets on weight loss, blood pressure (BP) and lipid values in trials with dietary interventions with durations of at least six months. The final sample included five international RCTs. After six months, individuals assigned to low-CHO diets had lost more weight than individuals randomized to low-fat diets (weighted mean difference, -3.3kg; 95% CI: 5.3, -1.4kg).

Primary Articles (31)

Randomized Controlled Trials (30)

Arvidsson et al, 2004 (positive quality) conducted an RCT in Sweden to test the effects on body weight and protein secretion of 10-week moderate hypoenergetic (-600kcal per day) diets with either low-fat, high-CHO content or moderate-fat, moderate-CHO content. Subjects were randomly assigned to either the low-fat, high-CHO diet (20% to 25% fat, 15% to 20% PRO, 60% to 65% CHO, N=20) or the moderate-fat, moderate-CHO diet (40% to 45% fat, 15% to 20% PRO, 40% to 45% CHO, N=20). Subjects visited or had telephone contact with the dietitian every week during the 10-week intervention, and dietary intake was assessed using daily food diaries. All 40 women completed the trial (mean age 35 years; mean BMI 37kg/m^2), with 20 subjects in the low-fat, high-CHO group and 20 subjects in the moderate-fat, moderate-CHO group. Similar results were obtained for both diets; body weight decreased by approximately 7.5% (7.7±0.4kg). Both groups also had similar significant reductions in percent body fat, BMI and fat cell volume.

Benassi-Evans et al, 2009 (positive quality) conducted an RCT in Australia to compare the effects of high-CHO, low-red-meat and high-PRO, high-red-meat weight loss diets on genome stability in peripheral blood lymphocytes in overweight men. Subjects were assigned to one of two isocaloric, energy-restricted diets: High CHO (17% PRO, 58% CHO, 25% fat, N=17) or high-PRO, high-red-meat (35% PRO, 40% CHO, 25% fat, N=16) diets for 12 weeks, followed by a 52-week weight maintenance period. Subjects met with the dietitian every two weeks for the first 12 weeks of the study and then monthly until one year. Dietary intake for six days a month was assessed using checklists. All 33 men completed the trial (mean age approximately 54 years; mean BMI 32kg/m^2), with 17 subjects in the high-CHO group and 16 subjects in the high-PRO group. Both diets produced an average weight loss of 9.3±0.7kg after 12 weeks.

Bopp et al, 2008 (positive quality) conducted a retrospective analysis of a RCT conducted in the US to determine whether dietary PRO intake was associated with a loss of lean mass during a caloric restriction and exercise weight-loss intervention in post-menopausal women. The study had three intervention groups, diet-only, diet and low-intensity aerobic exercise and diet and high-intensity aerobic exercise. The diet-only group reduced caloric intake by 2,800 kcal per week, and the diet-and-exercise groups reduced caloric intake by 2,400kcal per week and expended approximately 400kcal per week through aerobic exercise (either low intensity or high intensity). All meals were provided to participants. All 70 women completed the trial (mean age 58 years; mean BMI 33kg/m^2), with 24 in the diet-only group, 24 in the low-intensity exercise group and 22 in the high-intensity exercise group. Weight loss did not differ between intervention groups and averaged 10.8±4.0kg, 32% of which was lean mass. To investigate the effects of PRO intake on changes in body composition, data from all subjects was combined and logistic regression analyses were performed. Macronutrient intake distribution for all subjects averaged 52% CHO, 27% fat, and 17% PRO (0.62g per kg body weight per day). Participants who consumed higher amounts of dietary PRO lost significantly less total lean mass and appendicular lean mass (R=0.3, P=0.01 and R=0.41, P<0.001, respectively), and there was a significant correlation between PRO intake and absolute fat mass loss (R=0.37, P=0.001), though the direction of the relationship was not reported.

Buscemi et al, 2009 (positive quality) conducted an RCT in Italy to test the effects of two hypocaloric diets, a very-low-CHO and a Mediterranean diet, on weight loss and endothelial function. Subjects were randomly assigned for two months to either a very-low-CHO diet (20% CHO, 55% fat, 25% PRO) or a Mediterranean diet (55% CHO, 25% fat, 20% PRO). Subjects met with a dietitian weekly, and a three-day food record was collected every two weeks to assess compliance to the study protocol. The final sample included 20 women (age 30 to 50 years, BMI 27 to 34.9kg/m^2), with 10 in the very-low-CHO group and 10 in the Mediterranean diet group. Attrition was 20%. Subjects in the very-low-CHO group lost more weight (-7.6±0.8kg) than the Mediterranean diet group (-4.9±0.6kg; P=0.014).

Capel et al, 2008 (positive quality) conducted a multi-center RCT in Europe to investigate effects on weight loss and adipose tissue gene expression of consuming energy-restricted diets that vary in macronutrient composition. Participants were women from the Nutrient-Gene Interaction in Human Obesity (NUGENOB) trial. Participants were randomly assigned to one of two calorie-restricted (-600 kcal per day) diets for 10 weeks, either the low-fat, high-CHO diet (23% fat, 59% CHO, 18% PRO) or the moderate-fat, low-CHO diet (42% fat, 41% CHO, 17% PRO). Subjects in each diet group were matched for high quality of adipose tissue RNA, weight, height, BMI, waist-to-hip ratio, energy intake, macronutrient intake and alcohol intake. All 94 women completed the trial (mean age approximately 37 years; mean BMI 35kg/m^2), with 47 subjects in each diet group. Results showed that both diet groups experienced significant weight loss (-6.8±0.2kg), but there were no differences between the diet groups. Both groups also experienced similar reductions in fat mass (-5.2±0.2kg), fat-free mass (-1.6±0.2kg) and BMI (-2.5±0.1kg/m^2). In addition, while 1,000 genes were regulated for energy restrictions, only five genes were affected by the macronutrient composition of the diet.

de Luis et al, 2009 (positive quality) conducted an RCT in Spain to compare the effect of two diets on weight and circulating GLP-1 levels and the relation to insulin response after weight loss. Subjects were randomly assigned to a 1,500 kcal diet, either low-CHO (38% CHO, 36% fat, 26% PRO) or low-fat (52% CHO, 27% fat, 20% PRO) for three months. Compliance with the diet interventions was assessed using three-day food records. All 118 subjects completed the trial (33 men, 85 women; mean age 45.6±16.5 years; mean BMI 35.4±5.7kg/m^2), with 52 subjects in the low-CHO group and 66 subjects in the low-fat group. Both groups lost weight and decreased fat, but there were no differences between the diet groups. Subjects in the low-CHO group decreased weight from 93.8±20.1kg to 90.4±19.7kg and fat mass from 38.5±13kg to 36.5±23.6kg (P<0.05). Subjects in the low-fat group decreased weight from 91.5±20.4kg to 87.5±10.1kg and fat mass from 40.2±10.9kg to 37.2±10.1kg (P<0.05).

Frisch et al, 2009 (positive quality) conducted an RCT in Germany to investigate whether the macronutrient composition of an energy-restricted diet influences the efficacy of a telemedically guided weight loss program. Subjects were assigned to either a low- CHO diet (less than 40% CHO, more than 35% fat, 25% PRO) or a low-fat diet (less than 30% fat, more than 55% CHO, 15% PRO). The intervention was delivered for six months, when subjects received nutrition education and dietary counseling by phone. Anthropometric, body composition and biochemical parameters were measured at baseline, six and 12 months. The final sample included 165 subjects (mean age 47±10.5 years; mean BMI = 33kg/m^2). Attrition rate was 17%. In both groups, energy intake decreased by 400kcal per day within the first six months and increased slightly during the second six months. After six months, weight loss was NS different between groups, with the low-CHO group losing 7.2± 5.4kg, and the low-fat group losing 6.2±4.8kg.

Halyburton et al, 2007 (positive quality) conducted an RCT in Australia to compare the effects on mood and cognitive function of a low-CHO, high-fat diet and a high-CHO, low-fat diet. Subjects were randomly assigned to moderately energy-restricted diets (30% energy deficit) for eight weeks that were either low-CHO, high-fat (35% PRO, 58% fat, 5% CHO) or high-CHO, low-fat (24% PRO, 28% fat, 47% CHO). Subjects were counseled by a dietitian at baseline and every two weeks and three-day food records kept every two weeks were used to assess compliance. The final sample consisted of 93 subjects (mean age 50±0.8 years; mean BMI 33.6±0.4kg/m^2), with 48 in the low-CHO diet (18 men, 30 women) and 45 in the high-CHO diet group (19 men, 26 women). Attrition rate was 13%. Subjects in the low-CHO group lost significantly more weight (7.8±0.4kg) than those in the high-CHO diet group (6.4±0.4kg; P=0.04).

Jenkins et al, 2009 (neutral quality) conducted an RCT in Canada to determine the effect of a low-CHO weight loss diet, without the use of animal products, on serum lipid concentrations compared with a higher CHO diet. This parallel-arm design study was one month in length, and subjects were provided with all food during the intervention. The intervention diets were a low-CHO, plant-based diet (26%, 130g per day CHO, 31% PRO, 43% fat), or a high-CHO, lacto-ovo vegetarian diet (58% CHO, 16% PRO, 25% fat). The final included 44 subjects (18 men and 26 post-menopausal women; mean age of 57 years; mean BMI 31kg/m^2), with 22 subjects

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in each intervention group. Attrition rate was 6%. Weight loss did not differ between diet groups, with both groups losing approximately 4.0kg over one month.

Johnston CS et al, 2006 (positive quality) conducted an RCT in the US to compare the effects on weight loss of either a ketogenic, low-CHO diet and a non-ketogenic, low-CHO diet. The trial lasted six weeks, and all food consumed was provided to participants. The intervention diets were a ketogenic, low-CHO diet (60% fat, 9% CHO, 33% PRO) and a non-ketogenic, low-fat, low-CHO diet (30% fat, 42% CHO, 31% PRO). The final sample included 19 subjects (mean BMI = 34.4±1.0kg/m^2, mean age of 38 years), with nine in the ketogenic group (two men, seven women) and 10 in the non-ketogenic group (two men, eight women). Attrition rate was 5%. All subjects significantly reduced body weight over the six-week intervention, (6.3±0.6kg in the ketogenic group and 7.2±0.8kg in the non-ketogenic group), but the difference between groups was NS.

Johnstone AM et al, 2008 (positive quality) conducted a randomized crossover trial in the UK to compared the effects of consuming high-PRO diets with varied CHO content on hunger, appetite and weight loss. Using a cross-over design, subject consumed each intervention diet for four weeks with a three-day wash-out period in between. All food was provided to subjects. The intervention diets were both high in PRO and one was a ketogenic, low-CHO diet (30% PRO, 4% CHO, 66% fat), while the other was a non-ketogenic, moderate-CHO diet (30% PRO, 35% CHO, 35% fat). The final sample included 17 men (mean age 38±10 years; mean BMI was 35.1±3.8kg/m^2). Attrition rate was 15%. Weight loss was significantly greater on the low-CHO diet compared to the moderate-CHO diet (-6.34kg vs. -4.35kg, respectively, P=0.006). Also, ad libitum energy intakes (7.25 vs.7.95mJ per day, respectively, P=0.02) and hunger ratings (P=0.014) were significantly lower on the low-CHO diet compared to the moderate-CHO diet.

Keogh et al, 2008 (positive quality) conducted a RCT in Australia to examine the effect of diets with different macronutrient content on weight loss and cardiovascular risk factors. Participants were matched for age, sex and BMI and randomly assigned to either the energy-restricted very-low-CHO diet (4% CHO, 61% fat, 35% PRO) or an isocaloric conventional high-CHO, low-saturated fat diet (46% CHO, 30% fat, 24% PRO) for eight weeks. Three-day food records were collected every two weeks to assess compliance. The final sample included 99 subjects (age 50 years, BMI 34 kg/m^2), with 52 in the low-CHO group and 47 in the high-CHO group. Attrition rate was 7%. Weight loss occurred in both groups over the eight-week intervention period (P<0.001) and was significantly greater in the low-CHO group (-8%, -7.5±2.6kg) than in the high-CHO group (-7%, -6.2±2.9kg). Both groups lost a significant amount of fat mass (-5.3±2.5kg in the low-CHO group and -4.9±3.6kg in the high-CHO group), but the difference was NS.

Leidy et al, 2007 (positive quality) conducted an RCT in the US to investigate the effects of high-PRO and normal-PRO energy-restricted diets on body weight, body composition, appetite, mood and markers of cardiovascular and kidney functions. Participants were randomly assigned to one of two groups and consumed either a higher-PRO diet (30% PRO, 45% CHO, 25% fat) or normal-PRO diet (18% PRO, 57% CHO, 25% fat) for 12 weeks. Subjects were provided all foods consumed during the intervention and each diet was designed to have a -750 kcal per day deficit. The final sample included 46 women (mean age 50±2 years, mean BMI 31kg/m^2), who were retrospectively grouped according to BMI: Pre-obese (BMI 25.0 to 29.9kg/m^2) or obese (30.0 to 37.0kg/m^2). Attrition rate was 15%. Analyses were run using the four groups: High-PRO, pre-obese (N=9); normal-PRO, pre-obese (N=11); high-PRO, obese (N=12); and normal-PRO, obese (N=14). All subjects lost weight, fat mass and lean body mass (P<0.001). With comparable weight loss, lean body mass losses were less in high-PRO vs. normal-PRO (-1.5±0.3 vs. -2.8±0.5, P<0.05) and pre-obese vs. obese (-1.2±0.3 vs. -2.9±0.4kg, P<0.005). The women in the high-PRO, pre-obese group lost less lean body mass than those in the normal-PRO, obese group (P<0.05). In addition, the energy-restriction-induced decline in satiety was less pronounced in the high-PRO groups than the normal PRO groups (P<0.005).

Lim et al, 2009 (neutral quality) conducted an RCT in Australia to compare the changes in weight and other cardiovascular risk factors associated with three isocaloric energy-restricted diets to no-intervention control after one year. Subjects were randomly allocated to either very-low- CHO (VLC; 60% fat, 4% CHO, 36% PRO), very-low-fat (VLF; 10% fat, 70% CHO, 20% PRO), high-unsaturated fat (HUF; 30% fat, 20% PRO, 50% CHO) with intensive support for three months followed by minimal support for 12 months, while the control group received no intervention. The final included 104 subjects (age 47±10 years; BMI of 32±6 kg/m^2), with 30 subjects in the VLC group, 30 subjects in the VLF group, 30 subjects in the HUF group and 23 subjects in the control group. Attrition rate at 15 months was 34%. Weight change at three months did not differ between diet groups and was -8.0±2.8kg for VLC, -6.7±3.5kg for VLF and -6.3±2.9kg for HUF.

López-Fontana et al, 2009 (positive quality) conducted an RCT in Spain to investigate the impact on body composition and weight of habitual physical activity and the CHO-fat distribution in two hypocaloric diets. Subjects were randomly assigned to a high- (55% to 60% CHO, 25% to 30% fat, 15% to 20% PRO) or low-CHO (40% to 45% CHO, 35% to 40% fat, 15% to 20% PRO) for 10 weeks. Subjects were provided with detailed meal plans and instructions and kept daily food records to monitor compliance with the study protocol. The final sample included 40 women (mean age 34 years; mean BMI 37.1±6.1kg/m^2), with 19 subjects in the low-carb group and 21 subjects in the low-fat group. Both the low-carb and low-fat groups lost weight (-7.82±2.84kg and -7.34±2.68kg) and fat mass (-6.23±2.66kg and -6.07±2.74kg) and there were no differences between the groups.

Mahon et al, 2007 (positive quality) conducted an RCT in the US to compare the short-term effects of dietary PRO intake on energy restriction (ER)-induced changes in body weight and body composition. Subjects were randomly assigned to one of three dietary interventions for nine weeks; total energy intake was 1,250kcal per day (1,000kcal per day basal diet and 250kcal from beef, chicken or non-meat CHO and fat foods). The beef diet was 24% PRO, 46% CHO and 30% fat; the chicken diet was 25% PRO, 51% CHO and 24% fat; the CHO diet was 17% PRO, 59% CHO and 24% fat. The final sample included 54 women (mean age 58 ± 2 years; BMI 30kg/m^2), 14 in the beef group, 15 in the chicken group and 14 in the carb group, while a control group of 11 subjects consumed their habitual diets. Attrition rate was 5%. Energy intake was lower in the energy-restricted diet groups compared to the control group, but did not differ among groups. For all energy-restricted diet groups combined, body weight (-6.7±2.4kg, 9%), fat mass (-4.6±1.9kg, 13%) and fat-free mass (-2.1±1.1kg, 5%) decreased. Body weight loss differed among the groups, with the chicken group losing -7.9± 2.6kg $_a$, the beef group lost -6.6±2.7kg$_{a,b}$, the carb group lost -5.6±1.8kg$_b$ and control group lost -1.2±1.2 kg$_c$ (values with different superscripts differ, P<0.05).

McAuley et al, 2005 (positive quality) conducted an RCT in New Zealand to compare the effects on weight loss of consuming either a high-fat Atkins diet; a high-PRO Zone diet; or high-CHO, high-fiber diet in obese, insulin-resistant women. The weeks one to eight of the study were intended to be a weight-loss phase, weeks eight to 16 were a weight maintenance phase with similar supervision as the weight loss phase and for weeks 16 to 24 subjects were asked to continue following the intervention, but had no contact with the research team. None of the diets were formally energy-restricted and ad libitum consumption was advised for all subjects. The high-fat diet groups consumed 11% CHO, 29% PRO and 57% fat from one to eight weeks, and 26% CHO, 24% PRO and 46% fat from weeks eight to 24. The high-PRO group consumed 34% CHO, 28% PRO and 35% fat from weeks one to 24. The high-CHO group consumed 49% CHO, 21% PRO and 24% fat from weeks one to 24. The final sample included 84 women (mean age 45 years, mean BMI higher than 27kg/m^2), 31 on the high-fat diet, 30 on the high-PRO diet and 32 on the high-CHO diet. Attrition rate was 12%. There were no differences in reported energy in all groups during the six-month trial. Between baseline and eight weeks, the high-fat group (96.0±10.8kg to 89.4±10.3kg), the high-PRO group (93.2±14.5kg to 87.8±13.7kg) and the high-CHO group (98.0±15.1kg to 93.7±14.5kg) all lost weight, with the high-fat and high-PRO groups losing more weight than the high-CHO group.

McLaughlin et al, 2006 (positive quality) conducted an RCT in the US to evaluate the effects of calorie-restricted diets with varying macronutrient composition on weight loss in obese, insulin-resistant adults. Subjects were assigned to a 16-week calorie-restricted diet that was either high-CHO (60% CHO, 25%, 15% PRO) or low-CHO (40% CHO, 45% fat, 15% PRO). Subjects were instructed in their diet by a registered dietitian and kept daily food records to verify compliance with the intervention diets. The final sample included 57 subjects (mean BMI of 33kg/m^2), with 30 in the high-CHO group (39% male, 61% female, mean age 53±10 years) and 27 in the low-CHO group (46% male, 54% female, mean age 48±11 years). Attrition rate was 12%. All subjects lost weight (5.7±0.7kg in the high-CHO group and 6.9±0.7kg in the low-CHO group) with NS difference between groups.

McMillan-Price et al, 2006 (positive quality) conducted an RCT in Australia to determine the effects on weight and body composition of low-glycemic index (GI) and high-PRO diets. Subjects were stratified according to weight and sex and then randomly assigned to one of four reduced-energy diets for 12 weeks: high-CHO, high-GI (55% CHO, 15% PRO, 30% fat); high-CHO, low-GI (55% CHO, 15% PRO, 30% fat); high-PRO, high-GI (45% CHO, 25% PRO, 30% fat); or high-PRO, low-GI (45% CHO, 25% PRO, 30% fat). The final sample included 116 subjects (85 women, 31 men, aged 18 to 40 years, BMI higher than 25kg/m^2). Attrition rate was 10%. There were 27 subjects in the high-CHO, high-GI group; 30 in the high-CHO, low-GI group; 31 in the high-PRO, high-GI group; and 28 in the high-PRO, low-GI group. All groups lost weight (-3.7±0.5kg for high-CHO, high-GI; -4.8±0.5kg for high-CHO, low-GI; -5.3±0.5kg for high-PRO, high-GI; and -4.4±0.5kg for high-PRO, low-GI), but there were no differences between groups. Women on the high-CHO, low-GI and the high-PRO, high GI diets lost more weight than those on the high-CHO, high-GI diet (-4.8±0.5kg and -5.4±0.5kg vs. -3.1±0.5kg, P=0.006).

Miller LE et al, 2009 (positive quality) conducted an RCT in the US to examine changes in weight and body composition among women following a high-CHO vs. low-CHO diet. Subjects were randomized to one of two diets: A low-CHO, high-PRO diet (less than 20g CHO in the first two weeks, with 5g increases per week during weeks three to 10, and 60g CHO during weeks 11 and 12) or a high-CHO, low-fat diet (60% CHO, 15% PRO, 25% fat) for 12 weeks. The final sample included 25 women (mean age 39.4±3.4 years; mean BMI 30.5±5.1kg/m^2), with 13 women in the low-CHO, high-PRO diet group and 12 women in the high-CHO, low-fat diet group. Women in both diet groups reduced body weight (-6.7±2.7kg), but there were no differences between the two diet groups (P<0.0001). Both groups also reduced BMI, fat-free soft tissue mass, fat mass, body fat percentage and central abdominal fat over the 12-week trial (P<0.001 for all) and changes were NS different between groups.

Nickols-Richardson et al, 2005 (positive quality) conducted an RCT in the US to compare the effects of a low-CHO, high-PRO diet with a high-CHO, low-fat diet on self-reported scores of hunger and cognitive eating restraint in overweight pre-menopausal women during a six-week weight-loss intervention. Women were randomized to either the low-CHO, high-PRO diet (no caloric restriction, less than 20g CHO for first two weeks, increased 5g per week to 40g CHO at week six; 12% CHO, 26% PRO, 61% fat) or the high-CHO, low-fat diet (1,500 to 1700kcal per day, 60% CHO, 18% PRO, 22% fat). Four-day food records were completed at baseline, and weeks one, two, four and six to assess compliance with study protocol; all subjects attended weekly education sessions with a registered dietitian. The final sample included 28 women (with a BMI higher than 25kg/m^2 and lower than 40kg/m^2), with 13 in the low-CHO group (mean age 38.8±6.2 years) and 15 in the high-CHO group (mean age 40.1±6.3 years). All women experienced a reduction in body weight (P<0.01) although relative body weight loss was greater in the low-CHO, high-PRO group (5.7% lost; 84.6±12.7kg to 78.2±15.9kg) compared with the high-CHO, low-fat group at week six (3.3% lost; 79.8±12.1kg to 75.6±15.4kg) (P<0.05). In addition, self-rated hunger scores decreased in the low-CHO diet group (P<0.03) compared with the high-CHO diet group. Self-reported cognitive eating restraint increased in both groups (P<0.01).

Noakes et al, 2006 (positive quality) conducted an RCT in Australia to compare the effects of a very-low-CHO, very-low-fat and a high-unsaturated fat diet on body composition and cardiovascular risk. Subjects were randomly assigned to one of three isocaloric diets for eight weeks of weight loss, followed by four weeks of energy balance: Very-low-fat (70% CHO, 10% fat, 20% PRO); high-unsaturated fat (70% CHO, 10% fat, 20% PRO); very-low-CHO (4% CHO, 61% fat, 20% PRO). Detailed dietary instruction and meal plans were provided to subjects every two weeks by a registered dietitian and daily dietary checklists were used to assess compliance with the study protocol. The final sample included 67 subjects (55 women and 12 men; mean age 48±8 years; mean BMI 33±3kg/m^2), with 24 on the very-low-CHO diet, 22 on the very-low-fat diet and 21 on the high-unsaturated fat diet. Attrition rate was 19%. Each diet group lost weight over the eight-week energy restriction period and maintained this weight during the subsequent four-week period. There were NS differences in weight loss by diet composition; the very-low-CHO group lost 8.0±0.6kg, the very-low-fat group lost 6.7±0.7kg and the high-unsaturated fat group lost 6.4±0.6kg. Percent fat loss also did not differ between the diets; the very-low-CHO group lost -4.5±0.5%, the very-low-fat group lost -4.0±0.5% and the high-unsaturated fat group lost -4.4±0.6%.

Rankin et al, 2007 (positive quality) conducted an RCT in the US to determine the effects of weight loss diet macronutrient composition on weight loss, inflammation and oxidative stress. Subjects were randomly assigned to one of two self-selected diets, either a low- CHO diet (10% CHO, 60% fat, 30% PRO) or a high-CHO diet (60% CHO, 20% to 25% fat, 15% to 20% PRO) for four weeks. Weekly group sessions and four-day food records were used to assess compliance with the study protocol. The final sample included 29 women (aged 32 to 45 years; mean BMI 32.1±5.4kg/m^2). Attrition rate was 9%. Both groups lost weight, but the low-CHO group (-3.8±1.2kg) lost more weight than the high-CHO group (-2.6±1.7kg) (P=0.04).

Sacks et al, 2009 (positive quality) conducted an RCT in the US to examine the effects on body weight of energy-reduced diets with differing macronutrient composition. Subjects were randomly assigned to one of four energy-reduced (-750 kcal per day) diet groups: Low-fat, average PRO (20% fat, 15% PRO, 65% CHO); low-fat, high PRO (20% fat, 25% PRO, 55% CHO); high-fat, average PRO (40% fat, 15% PRO, 45% CHO); or high-fat, high-PRO (40% fat, 25% PRO, 35% CHO). Subjects were offered group and individual counseling session for two years and daily web-based food records were used to assess compliance with the study protocol. Weight measurements were taken at baseline, six months and two years. The final sample included 645 subjects (397 women, 248 men; mean age 52 years; mean BMI 33kg/m^2). Attrition rate at two years was 20%. After six months, participants had lost an average of 6kg (approximately 7% of initial weight), but began to regain weight after 12 months, with no differences between the groups.

Shai et al, 2008 (positive quality) conducted an RCT in Israel to compare the effectiveness and safety of three diets with varying macronutrient composition. Subjects were randomly assigned to either a low-fat diet (50% CHO, 30% fat, 20% PRO), a Mediterranean diet (50% CHO, 32% fat, 18% PRO) or a low-CHO diet (40% CHO, 22% PRO, 38% fat). The first six months of the trial was the weight loss phase, followed by 18 months of weight maintenance. Adherence to the study diets was assessed using a food-frequency questionnaire (FFQ). Weight was assessed monthly, but only 24-month data is reported. The final sample included 272 subjects (86% males; mean age 52 years; mean BMI 31kg/m^2). Attrition at two years was 16%. All groups lost weight over the 24 month trial; the low-CHO group lost -5.5±7.0kg, the Mediterranean-diet group lost -4.6±6.0kg and the low-fat group lost -3.3±4.1kg (P=0.03 for the comparison between the low-fat and low-CHO groups at 24 months).

Tay et al, 2008 (positive quality) conducted an RCT in Australia to compare the effects on weight loss and cardiovascular disease risk factors of moderate energy-restricted diets with different macronutrient composition. Subjects were randomly assigned to either a very-low-CHO, high-fat diet (VLCHF: 4% CHO, 35% PRO, 61% fat) or a high-CHO, low-fat diet (HCLF: 46% CHO, 24% PRO, 30% fat). Participants were provided with some food to enhance compliance with the dietary interventions and three-day food records were kept every two weeks to assess dietary intake. After the first eight weeks, subjects assigned to the VLCHF diet were then given the option to increase CHO intake to less than 40 g per day for the remaining 16 weeks, while subjects assigned to the HCLF diet were asked to restrict saturated fat intake to less than 10g per day for the study duration. The final sample included 88 subjects completed the trial (aged 18 to 65 years; mean BMI 34kg/m^2), with 45 subjects in the VLCHF group and 43 in the HCLF group. Attrition rate was 19%. Weight loss was similar in both groups, as VLCHF subjects lost -11.9±6.3kg and HCLF subjects lost -10.1±5.7kg.

Viguerie et al, 2005 (neutral quality) conducted an RCT investigate the effects of nutrient composition and energy restriction on weight loss among subjects enrolled in the NUGENOB (Nutrient-Gene Interactions in Human Obesity) program in Europe. Subjects were randomly assigned to one of two similarly energy-restricted diets for 10 weeks: a high-fat, low-CHO diets (42% fat, 40% CHO, 18% PRO) or a low-fat, high-CHO diet (24% fat, 59% CHO, 17% PRO). During the dietary intervention, the subjects either visited or had telephone contact with the dietitian every week to assess compliance and check the content of the diet from food diaries. The final sample included 50 women (ages 21 to 49 years; mean BMI 36kg/m^2), with 25 subjects in the high-fat, low-CHO group and 25 in the low-fat, high-CHO group. Results showed that subjects reduced weight on both the high-fat (99.4±2.7kg to 92.7±2.8kg; P<0.0001) and low-fat (100.3±3.9kg to 93.5±4.1kg; P<0.0001). Subjects also reduced fat mass on both the high-fat (43.5±2.0kg to 37.7±2.0kg; P<0.0001) and low-fat (43.7±2.7kg to 37.2±2.6kg; P<0.0001). However, there were no differences in the effects on weight and fat mass between the two diet types.

Volek et al, 2009 (positive quality) conducted an RCT in the US to test the effects of consuming diets with differing macronutrient proportions [carbohydrate-restricted diet (CRD) vs. low fat diet (LFD)] for 12 weeks on

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body weight and metabolic syndrome risk factors in overweight adults with atherogenic dyslipidemia. Subjects following the CRD diet consumed an average of 1,504kcal per day; 12% CHO, 59% fat, 28% PRO. Subjects on the LFD diet consumed an average of 1,478kcal per day; 56% CHO, 24% fat, 20% PRO. Subjects received weekly counseling throughout the study and seven-day food records were collected at weeks one, six and 12 to assess compliance. The final sample included 40 adults (ages 18 to 55 years; mean BMI 33kg/m^2), with 20 subjects in the CRD group and 20 subjects in the LFD group. Despite similar reductions in calories, weight loss in the CRD groups was significantly greater (96.5±13.7kg to 86.4±12.0kg) than in the LFD group (94.4±15.2kg to 89.2±13.9kg) (P<0.0001). Whole body fat mass also decreased significantly more in CRD subjects (38.7±7.7kg to 33.1±7.9) than in LFD subjects (37.1±10.0kg to 33.4±9.4kg) (P<0.01).

Wal et al, 2007 (neutral quality) conducted an RCT in the US to compare the efficacy of a low-fat, high-fiber, moderate-CHO diet; a low-CHO Atkins-type diet; and a control diet for weight loss and cardiovascular risk reduction in adults. A registered dietitian instructed participants in each of the three diet groups: 1) Control Diet: Participants in the Control diet were instructed to follow their normal daily routines for four weeks; 2) Low-CHO Diet: Breakfast: An Atkins Shake, Atkins Breakfast Bar and a selection of either fruit or yogurt; Lunch: Atkins-consistent lunch planned by the dietitian according to each participant's preferences; Dinner: A 2,512 kJ dinner consisting of the shake, bar, fruit and salad with fat-free dressing; and 3) Moderate-CHO Diet: Breakfast: Special K Low-CHO ready-to-eat cereal with low-fat milk; Lunch: Special K Low-carb ready-to-eat cereal with low-fat milk; Dinner: A 2,512kJ dinner consisting of fruits, salad with fat-free dressing and a low-fat, low-calorie meal planned by the dietitian according to each participant's preferences. The final sample included 125 subjects (25 men, 112 women; mean age 50 years; mean BMI 35kg/m^2), with 44 in the Control group, 41 in the Low-CHO group and 40 in the Moderate-CHO group. Attrition rate was 9%. Results showed that the Low-CHO (-2.94±2.25kg) and Moderate-CHO (-2.6±2.39kg) groups lost significantly more weight than the Control group (-0.61±1.33kg) (P<0.0001); however, mean weight loss did not differ between Low- and Moderate-CHO groups.

White et al, 2007 (positive quality) conducted an RCT in the US to explore how low-CHO diets impact weight loss, desire to exercise, fatigue and perceived effort during exercise in untrained, overweight adults. Subjects were randomly assigned to a diet for two weeks. The diets were: Ketogenic (5% CHO, 65% fat, 30% PRO) and non-ketogenic (40% CHO, 30% fat, 30% PRO). Participants were provided with all foods consumed during the two-week study period. Participants were served a hot lunch daily Monday through Friday; all other meals and snacks were packaged and consumed at home. The final sample included 19 subjects (four men, 15 women; mean age 38 years; mean BMI 34kg/m^2), with nine subjects in the ketogenic group and 10 subjects in the non-ketogenic group. Attrition rate was 10%. Results showed that both diets were equally effective at inducing weight loss (approximately 4kg after two weeks; P<0.0001).

Non-randomized Controlled Trials (1)

Gordon et al, 2008 (neutral quality) conducted a non-randomized controlled trial in older, overweight or obese women from the US to determine the effects on weight loss and loss of lean body mass of high- and low- PRO hypocaloric diets. The intervention diets were followed for 20 weeks and included a high-PRO hypocaloric diet (-2,800kcal per week; more than 1.2g per kg per day; 30% PRO, 45% CHO, 26% fat) and a low-PRO, hypocaloric diet (-2.800kcal per week; less than 0.8g per kg per day; 18% PRO, 54% CHO, and 28% fat). Women were provided all food consumed during the intervention, and women in the high-PRO group were given a PRO supplement to achieve higher PRO intake. Food records were used to assess compliance with the interventions diets. The final sample included 24 women (mean age = 58±6.6 years; mean BMI 33.0±3.6kg/m^2), with 15 women on the low-PRO diet, and nine women on the high-PRO diet. Attrition rate was 12%. Results showed that both PRO (P<0.0001) and fat (P<0.01) intake differed significantly between the two groups. Weight loss between the two groups did not differ significantly; the high-PRO group lost 8.4±4.5kg and the low-PRO group lost 11.2±3.8kg. However, the mean percentage of lean mass lost was significantly lower in the high-PRO group (17.3±27.8%) compared to the low-PRO group (37.5±14.6%; P=0.03).

View table in new window

Author, Year, Study Design, Class, Rating	Population	Intervention (Initial / Intense Phase)	Intervention (F/U / Maintenance Phase)	Macronutrient Composition of Diet	Weight Outcomes (End of Initial / Intense Phase)	Weight Outcomes (End of F/U / Maintenance Phase)	Safety Outcomes
Arvidsson et al 2004 Study Design: Randomized Clinical Trial Class: A Rating:	N=40 women. Age: 35 years. BMI: 37kg/m^2. N=20 in low-fat, high-CHO group; N=20 in moderate-fat, moderate-CHO group. Attrition: 0%.	Subjects were randomly assigned for 10 weeks to either: • Low-fat, high-CHO diet • Moderate-fat, moderate-CHO diet. Both diets were calorie restricted (-600kcal per day).	Not applicable.	Low-fat, high-CHO: 60% to 65%, 20% to 25%, 15% to 20%. Moderate CHO, moderate fat: 40% to 45%, 40% to 45%, 15% to 20%.	Both diets significantly ↓ body weight by 7.5% (7.7±0.4kg), but there were no differences between the diet groups. Both groups also had similar significant ↓ in % body fat, BMI and fat cell volume.	Not applicable.	Not applicable; study < six months.
Avenell A et al 2004 Study Design: Systematic Review Class: M Rating:	N=26 RCTs.	All studies included in the review were carried out for >one year.	Not applicable.	Low-fat diets: Advice given to reduce fat, >6.7mJ per day. Low-calorie diets (LCD): 4.2 to 6.7mJ per day. Very-low-calorie diets (VLCD): <4.2mJ per day. Protein-sparing modified fast (PSFM): ≤40g per day of CHO.	LFDs produced significant weight ↓ up to 36 months (-3.55kg, 95% CI: -4.54 to -2.55kg). VLCDs were associated with the most weight loss after 12 months (-13.40kg, 95% CI: -18.43 to -8.37kg) in one small study. There was no evidence that PSMFs were associated with greater long-term weight loss than LCDs or VLCDs.	Not applicable.	LFDs produced significant weight ↓ up to 36 months (-3.55kg, 95% CI: -4.54 to -2.55kg). VLCDs were associated with the most weight ↓ after 12 months (-13.40kg, 95% CI: -18.43 to -8.37kg) in one small study. There was no evidence that PSMFs were associated with greater long-term weight ↓ than LCDs or VLCDs.
Benassi-Evans et al 2009 Study Design: Randomized Clinical Trial Class: A Rating:	N=33 men. Age: 54 years. BMI: 32kg/m^2. N=17 in high-CHO group; N=16 in high-PRO group.	Subjects were assigned to one of two isocaloric, energy restricted diets for 12 weeks: • High-CHO, low-red-meat • High-PRO, high-red-meat diets. Subjects met with the dietitian every two weeks for the first 12 weeks of the study. Dietary intake for six days a month was assessed using checklists.	The initial 12-week intervention was followed by a 52-week weight maintenance period, during which time subjects met with the RD monthly.	High-CHO: 58%, 25%, 17%. High-PRO: 40%, 25%, 35%.	Both diets produced an average weight ↓ of 9.3±0.7kg after 12 weeks.	No further weight Δ occurred in the 52-week weight maintenance period.	There were NS differences between the diets with regards to any of the measures of genome stability and cell death in lymphocytes, including micronucleus frequency, nuclear buds, nucleoplasmic bridges, necrosis, apoptosis and nuclear division index.
Bopp MJ et al 2008 Study Design: Randomized Controlled Trial Class: A Rating:	N= 70 women. Age: 58 years. BMI: 33kg/m^2. N=24 in diet-only group; N=24 in low-intensity exercise group; N=22 in high-intensity exercise group. Attrition: 0%.	The 20-week trial had three intervention groups: • Diet-only • Diet and low-intensity aerobic exercise • Diet and high-intensity aerobic exercise. The diet-only group ↓ caloric intake by 2,800kcal per week and the diet-and-exercise groups ↓ caloric intake by 2,400kcal per week and expended ~400kcal per week through low- or	Not applicable.	52%, 27%, 17% (0.62g per kg per day).	Logistic regression showed that participants who consumed higher amounts of dietary PRO ↓ significantly less total lean mass and appendicular lean mass (R=0.3, P=0.01 and R=0.41, P<0.001, respectively). There was also a significant correlation between PRO intake and absolute fat mass loss (R=0.37, P=0.001), though the direction of the relationship was not reported.	Not applicable.	Not applicable; study <six months.

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		high-intensity aerobic exercise. All meals were provided to participants.					
Buscemi S, Verga S et al, 2009 Study Design: Randomized Controlled Trial Class: A Rating:	N=20 women. Age: 30 to 50 years. BMI: 27 to 34.9kg/m2. N=10 in very-low-CHO group; N=10 in Mediterranean diet group. Attrition: 20%.	Subjects were randomly assigned for two months to either: • Very-low-CHO diet • Mediterranean diet. Subjects met with a dietitian weekly and a three-day food record was collected every two weeks to assess compliance to the study protocol.	Not applicable.	Very-low CHO: 20%, 55%, 25%. Mediterranean diet: 55%, 25%, 20%.	Subjects in the very-low-CHO group ↓ more weight (-7.6±0.8kg) than the Mediterranean diet group (-4.9±0.6kg; P=0.014).	Not applicable.	Not applicable; study <six months.
Capel F et al 2008 Study Design: Randomized Clinical Trial Class: A Rating:	N= 94 women. Age: 37 years. BMI: 35kg/m2. N=47 in each diet group. Participants were from the NUGENOB trial in Europe.	Participants were randomly assigned to one of two calorie-restricted (-600kcal per day) diets for 10 weeks: • Low-fat, high-CHO diet • Moderate-fat, low-CHO diet. Subjects in each diet group were matched for high quality of adipose tissue RNA, weight, height, BMI, WHR, energy intake, macronutrient intake and alcohol intake.	Not applicable.	Low-fat, high-CHO: 59%, 23%, 18%. Moderate fat, low CHO: 41%, 42%, 17%.	Weight was ↓ significantly in both diet groups (-6.8±0.2kg), but there were no differences between the diet groups. Both groups also experienced similar ↓ in fat mass (-5.2±0.2kg), fat-free mass (-1.6±0.2kg) and BMI (-2.5±0.1kg/m2).	Not applicable.	Not applicable; study <six months.
de Luis D, Sagrado M et al, 2009 Study Design: Randomized Controlled Trial Class: A Rating:	N=118 subjects (33 men; 85 women). Age: 46 years. BMI: 35kg/m2. N=52 in low-CHO group; N=66 in low-fat group. Attrition: 0%.	Subjects were randomly assigned to a 1,500kcal diet, either low-CHO or low-fat, for three months. Compliance with the diet interventions was assessed using three-day food records.	Not applicable.	Low-CHO: 38%, 36%, 26%. Low-fat: 52%, 27%, 20%.	Both groups lost weight and fat, but there were no differences between the diet groups. The low-CHO group ↓ weight from 93.8±20.1kg to 90.4±19.7kg and fat mass from 38.5±13kg to 36.5±23.6kg (P<0.05). The low-fat group ↓ weight from 91.5±20.4kg to 87.5±10.1kg and fat mass from 40.2±10.9kg to 37.2±10.1kg (P<0.05).	Not applicable.	Not applicable; study <six months.
Frisch S et al 2009 Study Design: Randomized Controlled Trial Class: A Rating:	N=165. Age: 47 years. BMI: 33kg/m2. Attrition: 17%.	Subjects were assigned to a calorie-restricted diet (~-400kcal per day) that was either: • Low-CHO • Low-fat. The intervention was delivered for six months, when subjects received nutrition education and dietary counseling by phone. Anthropometric, body composition and biochemical parameters were measured at baseline and six months.	The weekly telephone counseling was discontinued during months six to 12. Anthropometric, body composition and biochemical parameters were measured at 12 months.	Low-CHO: <40%, >35%, 25%. Low-fat: >55%, <30%, 15%.	After six months, weight loss was NS different between groups. The low-CHO group ↓ 7.2±5.4kg and the low-fat group ↓ 6.2±4.8kg.	Between six and 12 months, weight regain between the groups was borderline significant (P<0.05), with the low-CHO group regaining less weight (1.6kg; 5.8±6.1kg lost) than the low-fat group (1.9kg; 4.3±5.1kg lost).	TG (-0.03±0.55mmol per L vs. -0.18±0.40mmol per L; P<0.001) and HDL-C levels (-0.09±0.19mmol per L vs. -0.02±0.20mmol per L; P<0.001) were significantly lower at six months. WC (-4.7±8.9cm vs. -6.9±6.1cm; P<0.05) and SBP (-1±15mmHg vs. -5±14mmHg; P<0.01) were significantly lower at 12 months in the low-CHO group compared to the low-fat group.
Gordon MM et al 2008 Study Design: Nonrandomized Clinical trial Class: C Rating:	N=24 women. Age: 58 years. BMI: 33kg/m2. N=15 on low-PRO diet; N=9 on the high-PRO diet. Attrition: 12%.	Intervention diets (-2,800kcal per week) were followed for 20 weeks; a high-PRO hypocaloric diet and a low-PRO, hypocaloric diet. All food consumed during the intervention was provided and the high-PRO group was given a PRO supplement to achieve ↑ PRO intake. Food records were used to assess compliance with the interventions diets.	Not applicable.	Low-PRO: 28%, 54%, 18% (<0.8g per kg per day). High-PRO: 26%, 45%, 30% (>1.2g per kg per day).	Weight loss did not differ between diet groups; High-PRO group ↓ 8.4±4.5kg and Low-PRO group ↓ 11.2±3.8kg. Mean lean mass ↓ was significantly lower in the high-PRO group (17.3±27.8%), compared to the low-PRO group (37.5±14.6%; P=0.03).	Not applicable.	Not applicable; study <six months.

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Halton TL et al 2004 Study Design: Systematic Review Class: M Rating:	N=50 studies.	All studies included in the review were carried out for <six months. The authors included studies that compared a diet relatively ↑ in PRO to a diet ↓ in PRO, but did not specify PRO levels.	Not applicable.	Not applicable.	Some evidence suggests that higher-PRO diets result in ↑ weight and fat loss compared to lower-PRO diets, but findings are inconsistent. There is strong evidence that higher-PRO intake ↑ dietary thermogenesis and satiety and ↓ subsequent energy intake compared to diets lower in PRO.	Not applicable.	Not applicable; study <six months.
Halyburton et al 2007 Study Design: Randomized Controlled Trial Class: A Rating:	N=93 subjects. Age: 50 years. BMI: 34kg/m2. N=48 in low-CHO diet group (18 men, 30 women); N=45 in high-CHO diet group (19 men, 26 women). Attrition: 13%.	Subjects were randomly assigned moderately energy-restricted diets (30% energy deficit) that were either: • Low-CHO, high-fat • High-CHO, low-fat. Subjects were counseled by a dietitian at baseline and every two weeks and three-day food records kept every two weeks were used to assess compliance.	Not applicable.	Low-CHO, high-fat: 5%, 58%, 35%. High-CHO, low-fat: 47%, 28%, 24%.	Subjects in the low-CHO group ↓ significantly more weight (7.8±0.4kg) than those in the low-CHO diet group (6.4±0.4kg; P=0.04).	Not applicable.	Not applicable; study <six months.
Hession M et al 2009 Study Design: Systematic Review Class: M Rating:	N=50 RCTs conducted in adults with ≥BMI 28 kg/m2 lasting for >six months.	Not applicable.	Not applicable.	Low-CHO: <60g per day CHO. Low-fat, low-calorie: <30% fat.	At six months, weight Δ was -4.02kg in favor of the low-CHO diets, compared to the low-fat/low-calorie diets (P<0.0001).	At 12 months,weight loss was still significantly less in the low-CHO diets, compared to the low-fat diets at -1.05kg (P<0.05).	Compared to low-fat/low-calorie diets, there were significant improvements in HDL-C (0.04mmol per L at six months and 0.06mmol per L at 12 months, P<0.05), TG (0.017mmol per L at six months and -0.19mmol per L at 12 months, P<0.05) and SBP (-1.35mmHg at six months and -2.19mmHg at 12 months, P<0.05) for subjects following low-CHO diets. The high-CHO diets resulted in significant ↑ in TC (0.19mmol per L, P<0.0001) at six months and in LDL-C (0.14mmol per L and 0.37mmol per L) at six and 12 months, respectively (P<0.00001), compared to the low-fat/low-calorie diets.
Jenkins DJ et al 2009 Study Design: Randomized Controlled Trial Class: A Rating:	N=44 (18 men; 26 post-menopausal women). Age: 57 years. BMI: 31kg/m2. N=22 in each intervention group. Attrition: 6%.	This parallel-arm design study was one month in length; subjects were provided with all food during the intervention. The diets were either: • Low-CHO • Plant-based diet • High-CHO, lacto-ovo vegetarian diet.	Not applicable.	Low-CHO: 26% (130g per day), 43%, 31%. High-CHO: 58%, 25%, 16%.	Weight loss did not differ between diet groups, with both groups ↓~4.0kg over one month.	Not applicable.	Not applicable; study <six months.
Johnston et al 2006 Study Design: Randomized Clinical Trial Class: A Rating:	N=19 subjects (four men; 15 women). BMI: 34kg/m2. Age: 38 years. N=9 in ketogenic group; 10 in non-ketogenic group. Attrition: 5%.	The trial lasted six weeks and all food consumed was provided to participants. The intervention diets were: • Ketogenic • Low-CHO diet • Non-ketogenic, low-fat, low-CHO diet.	Not applicable.	Ketogenic low-CHO: 9%, 60%, 33%. Non-ketogenic low-CHO: 42%, 30%, 31%.	Subjects significantly ↓ body weight over the six-week intervention (6.3±0.6kg in ketogenic group; 7.2±0.8kg in non-ketogenic group), but the difference between groups was NS.	Not applicable.	Not applicable; study <six months.
Johnstone et al 2008 Study Design: Randomized Crossover Trial Class: A Rating:	N=17 men. Age: 38 years. BMI: 35kg/m2. Attrition: 15%.	Using a cross-over design, subjects consumed each intervention diet for four weeks with a three-day wash-out period in between. All food was provided to subjects. The intervention diets were both high in PRO: • Ketogenic, low-CHO diet • Non-ketogenic,	Not applicable.	Ketogenic low-CHO: 4%, 66%, 30%. Non-ketogenic moderate-CHO: 35%, 35%, 30%.	Weight ↓was significantly greater on the low-CHO diet compared to the moderate-CHO diet (-6.34kg vs. -4.35kg, respectively, P=0.006). Ad libitum energy intakes (7.25 vs.7.95mJ per day, respectively, P=0.02) and hunger ratings (P=0.014) were significantly ↓ on the low-CHO diet compared to the moderate-CHO diet.	Not applicable.	Not applicable; study <six months.

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		moderate-CHO diet.					
Keogh et al 2008 Study Design: Randomized Controlled Trial Class: A Rating:	N=99. Age: 50 years. BMI: 34kg/m2. N=52 in low-CHO group; N=47 in high-CHO group. Attrition: 7%.	Participants were matched for age, sex and BMI and randomly assigned for eight weeks to either: • Energy-restricted very-low-CHO diet • Isocaloric conventional high-CHO, low-saturated fat diet. Three-day food records were collected every two weeks to assess compliance.	Not applicable.	Low-CHO: 4%, 61%, 35%. High-CHO: 46%, 30%, 24%.	Weight ↓ occurred in both groups over the eight-week intervention period (P<0.001) and was significantly greater in the low-CHO group (-8%, -7.5±2.6kg) than in the high-CHO group (-7%, -6.2±2.9kg). Both groups ↓ a significant amount of fat mass (-5.3±2.5kg in the low-CHO group, and -4.9±3.6kg in the high-CHO group), but the difference was NS.	Not applicable.	Not applicable; study was < six months.
Krieger JW et al 2006 Study Design: Meta-analysis Class: M Rating:	N=87 studies involving a dietary intervention that were published between 1950 and 2005, had subjects older than 19 years of age and involved pre- and post-dietary measurements of body mass or body composition. Studies that used self-reported dietary intake were required to have a biological marker measurement as an objective measure of compliance.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.
Leidy et al 2007 Study Design: Randomized Clinical Trial Class: A Rating:	N=46 women. Age: 50 years. BMI: 31kg/m2. Subgrouped according to BMI: Pre-obese (25.0 to 29.9kg/m2) or obese (30.0 to 37.0 kg/m2). Four groups: 1) High-PRO, pre-obese (N=9) 2) Normal-PRO, pre-obese (N=11) 3) High-PRO, obese (N=12) 4) Normal-PRO, obese (N=14). Attrition: 15%.	Participants were randomly assigned to one of two groups and consumed either a high-PRO diet or normal-PRO diet for 12 weeks. Subjects were provided all foods consumed during the intervention and each diet was designed to have a -750kcal per day deficit.	Not applicable.	High-PRO: 45%, 25%, 30%. Normal-PRO: 57%, 25%, 18%.	All subjects ↓weight, fat mass and lean body mass (LBM) (P<0.001). LBM ↓ was less in high-PRO vs. normal-PRO (-1.5±0.3 vs. -2.8±0.5, P<0.05) and pre-obese vs. obese (-1.2±0.3 vs. -2.9±0.4kg, P<0.005). The high-PRO, pre-obese group ↓ less LBM than those in the normal-PRO, obese group (P<0.05). The energy-restriction-induced ↓ in satiety was less pronounced in the high-PRO groups than the normal-PRO groups (P<0.005).	Not applicable.	Not applicable; study <six months.
Lim et al 2009 Study Design: Randomized Controlled Trial Class: A Rating:	N=104 subjects. Age: 47 years. BMI: 32kg/m2. N=30 subjects in the VLC group; N=30 subjects in the VLF group; N=30 subjects in the HUF group; N=23 subjects in the control group. Attrition at 15 months: 34%.	Subjects were randomly allocated to: • Very-low-CHO (VLC) • Very-low-fat (VLF) • High-unsaturated fat (HUF) with intensive support for three months. The control group received no intervention.	The intensive three-month initial phase was followed by minimal support for 12 months.	VLC: 4%, 60%, 35%. VLF: 70%, 10%, 20%. HUF: 50%, 30%, 20%.	Weight Δ at three months did not differ between diet groups and was: • -8.0±2.8kg for VLC • -6.7±3.5kg for VLF • -6.3±2.9kg for HUF.	Weight Δ at 15 months did not differ between diet groups and was: • -3.0±0.2kg for VLC • -2.0±0.1kg for VLF • -3.7±0.1kg for HUF • SD from controls (+0.8±5.0kg; P<0.050). For all groups combined, weight loss at 15 months was significantly correlated to a: • Higher PRO intake (R=-0.38, P=0.0009) • Lower fat intake (R=0.31, P=0.037) • Higher fiber intake (R=-0.30, P=0.038).	At 15 months, there were NS differences in weight Δ or cardiovascular risk factors between groups.
Lopez-Fontana CM, Sanchez-Villegas A et al, 2009 Study Design: Randomized Controlled Trial Class: A Rating:	N=40 women. Age: 34 years. BMI: 37kg/m2. N=19 in low-CHO group; N=21 in low-fat group. Attrition: 0%.	Subjects were randomly assigned to a high- or low-CHO for 10 weeks. Subjects were provided with detailed meal plans and instructions and kept daily food records to monitor compliance with the study protocol.	Not applicable.	High-CHO: 55% to 60%, 25% to 30%, 15% to 20%. Low-CHO: 40% to 45%, 35% to 40%, 15% to 20%.	Both the low-CHO and low-fat groups ↓ weight (-7.82±2.84kg and -7.34±2.68kg) and fat mass (-6.23±2.66kg and -6.07±2.74kg). There were no differences between the groups.	Not applicable.	Not applicable; study <six months.
Mahon AK, Flynn MG et al, 2007 Study Design: Randomized controlled study. Class: A Rating:	N=54 women. Age: 58 years. BMI: 30kg/m2. N=14 in beef group; N=15 in chicken group; N=14 in CHO group; N=11 in control group. Attrition: 5%.	Subjects were randomly assigned to one of three dietary interventions for nine weeks; total energy intake was 1,250kcal per day (1,000kcal per day basal diet and 250kcal from beef, chicken or non-meat CHO and fat foods).	Not applicable.	Beef: 46%, 24%, 30%. Chicken: 51%, 25%, 24%. CHO: 59%, 17%, 24%.	Body weight (-6.7±2.4kg, 9%), fat mass (-4.6±1.9kg, 13%) and fat-free mass (-2.1±1.1kg, 5%) ↓ in all diet groups. Weight loss differed among the groups: • Chicken group ↓ -7.9±2.6kg[a] • Beef group ↓ -6.6±2.7kg [a,b]	Not applicable.	Not applicable; study < six months.

		Subjects in the control group ate their habitual diets.			• CHO group ↓ -5.6±1.8kg[b] • Control group ↓ -1.2±1.2kg[c] Values with different superscripts differ (P<0.05).		
McAuley KA et al 2005 Study Design: Randomized Controlled Trial Class: A Rating:	N=84 obese, insulin-resistant women. Age: 45 years. BMI: >27kg/m^2. N=31 on high-fat diet; N=30 on high-PRO diet; N=32 on high-CHO diet. Attrition rate: 12%.	Weeks one to eight of the study were a supervised weight ↓ phase. Subjects were randomized to one of three diet interventions: • High-fat diet (Atkins), • High-PRO diet (Zone) • High-CHO, high-fiber diet. None of the diets were formally energy-restricted and ad libitum consumption was advised for all subjects.	Weeks eight to 16 were a supervised weight maintenance phase. Weeks 16 to 24 were an unsupervised weight maintenance phase.	High-fat: 11%, 57%, 29%. High-PRO: 34%, 35%, 28%. High-CHO: 49%, 24%, 21%.	Between baseline and eight weeks, the high-fat group (96.0±10.8kg to 89.4±10.3kg), the high-PRO group (93.2±14.5kg to 87.8±13.7kg) and the high-CHO group (98.0±15.1kg to 93.7±14.5kg) all ↓ weight, with the high-fat and high-PRO groups losing more weight than the high-CHO group.	Between eight weeks and 24 weeks, the high-fat group (89.4±10.3kg to 88.9±10.6kg), the high-PRO group (87.8±13.7kg to 86.3±14.2kg) and the high-CHO group (93.7±14.5kg to 93.3±14.5kg) all maintained their initial weight loss.	Triglycerides decreased with all three diets, but the reductions were significantly greater in the high-fat diet and high-protein diet groups than the high-carbohydrate group diet group. Insulin levels decreased in all three groups, with no differences between the groups. LDL cholesterol levels were significantly higher in the high-fat diet group than in the high-protein diet group despite similar weight changes (P=0.02).
McLaughlin et al 2006 Study Design: Randomized Clinical Trial Class: A Rating:	N=57. BMI: 33 kg/m^2. N=30 in high-CHO group (39% male, age 53 years); N=27 in the low-CHO group (46% male, age 48 years). Attrition: 12%.	Subjects were assigned to a 16-week calorie-restricted diet that was either high-CHO or low-CHO. Subjects were instructed in their diet by an RD and kept daily food records to verify compliance with the intervention diets.	Not applicable.	High-CHO: 60%, 25%, 15%. Low-CHO: 40%, 45%, 15%.	All subjects ↓ weight (5.7±0.7kg in high-CHO group; 6.9±0.7kg in low-CHO group) with NS difference between groups.	Not applicable.	Not applicable; study <six months.
McMillan-Price et al 2006 Study Design: Randomized Controlled Trial Class: A Rating:	N=116 (85 women; 31 men) Age: 18 to 40 years, BMI: >25kg/m^2. N=27 in high-CHO, high-glycemic index (GI) group; N=30 in high-CHO, low-GI group; N=31 in high-PRO, high-GI group; N=28 in high-PRO, low-GI group. Attrition: 10%.	Subjects were stratified according to weight and sex and then randomly assigned to one of four reduced-energy diets for 12 weeks: • High-CHO, high-GI • High-CHO, low-GI • High-PRO, high-GI • High-PRO, low-GI.	Not applicable.	High-CHO, high-GI: 55%, 30%, 15%. High-CHO, low-GI: 55%, 30%, 15%. High-PRO, high-GI: 45%, 30%, 25%. High-PRO, low-GI: 45%, 30%, 25%.	All groups ↓ weight (-3.7±0.5kg for high-CHO, high-GI; -4.8±0.5kg for high-CHO, low-GI; -5.3±0.5kg for high-PRO, high-GI; and -4.4±0.5kg for high-PRO, low-GI), but there were no differences between groups. Women on the high-CHO, low-GI and the high-PRO, high GI diets ↓ more weight than those on the high-CHO, high-GI diet (-4.8±0.5kg and -5.4±0.5kg vs. -3.1±0.5kg, P=0.006).	Not applicable.	Not applicable; study < six months.
Miller et al 2009 Study Design: Randomized Clinical Trial Class: A Rating:	N=25 women. Age: 39 years. BMI: 31kg/m^2. N=13 women in low-CHO, high-PRO diet group; N=12 women in high-CHO, low-fat diet group.	Subjects were randomized to one of two diets for 12 weeks: • Low-CHO, high-PRO diet • High-CHO, low-fat diet.	Not applicable.	Low-CHO, high-PRO: <20g CHO in the first two weeks, with 5g per week ↑ during weeks three to 10. High-CHO, low-fat: 60% (210g per day), 25%, 15%.	Women in both diet groups ↓ body weight (-6.7±2.7kg), but there were no differences between the two diet groups (P<0.0001). BMI, fat-free mass, fat mass, body fat percent and abdominal fat also ↓ over the 12-week trial (P<0.001 for all) and Δs were not different between groups.	Not applicable.	Not applicable; study was < six months.
Nickols-Richardson SM, Coleman MD et al 2005 Study Design: Randomized Clinical Trial Class: A Rating:	N=28 women. BMI: >25kg/m^2 and <40kg/m^2. N=13 in the low-CHO group (age 39 years); N=15 in the high-CHO group (mean age 40 years).	Women were randomized to either: • Low-CHO • High-PRO diet • High-CHO, low-fat diet. Four-day food records were completed at baseline and weeks one, two, four and six to assess compliance with study protocol. All subjects attended weekly education sessions with an RD.	Not applicable.	Low-CHO, high-PRO: 12%, 61%, 26%. High-CHO, low-fat: 60%, 22%, 18%.	All women experienced a ↓ in body weight (P<0.01), but weight loss was greater in the low-CHO, high-PRO group (5.7% ↓; 84.6±12.7kg to 78.2±15.9kg), compared with the high-CHO, low-fat group at week six (3.3% ↓; 79.8±12.1kg to 75.6±15.4kg) (P<0.05).	Not applicable.	Not applicable; study <six months.
Noakes M, Foster P et al, 2006 Study Design: Randomized Controlled Trial Class: A Rating:	N=67 subjects (55 women and 12 men). Age: 48 years. BMI: 33kg/m^2. N=24 in very-low-CHO diet group; N=22 in very-low-fat diet group; N=21 in high-unsaturated fat diet group.	Subjects were randomly assigned to one of three isocaloric diets for eight weeks of weight loss: • Very-low-fat • High-unsaturated fat • Very-low-CHO. Detailed dietary instruction and meal plans were provided to subjects	The eight weeks of weight loss was followed by four weeks of energy balance following the same diet plans prescribed for weight loss.	Very-low-CHO: 4%, 61%, 20%. Very-low-fat: 70%, 10%, 20%. High-unsaturated fat: 70%, 10%, 20%.	NS differences in weight loss by diet composition: • Very-low-CHO group ↓ 8.0±0.6kg • Very-low-fat group ↓ 6.7±0.7kg • High-unsaturated fat group ↓ 6.4±0.6kg. Percent fat loss also did not differ between the diets:	Each diet groups ↓ weight over the eight-week energy-restriction period and maintained this weight during the subsequent four-week period.	Not applicable; study <six months.

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	Attrition: 19%.	every two weeks by an RD and daily dietary checklists were used to assess compliance with the study protocol.			• Very-low-CHO group ↓ -4.5±0.5% • Very-low-fat group ↓ -4.0±0.5% • High-unsaturated fat group lost -4.4±0.6%.		
Nordmann AJ et al 2006 Study Design: Meta-analysis Class: M Rating:	N=5 RCTs, with a total of 447 subjects.	A meta-analysis was done to compare the effects of low-CHO diets without energy restriction to energy-restricted low-fat diets on weight loss, BP and lipid values in trials with dietary interventions with duration of at least six months.	Not applicable.	Low-CHO: <60g per day CHO. Low-fat: <30% fat.	After six months, individuals assigned to low-CHO diets had ↓ more weight than individuals randomized to low-fat diets (weighted mean difference, -3.3kg; 95% CI: -5.3, -1.4kg).	The difference in weight loss between diets at six months was no longer obvious after 12 months (weighted mean difference, -1.0kg; 95% CI: -3.5, 1.5kg).	There were no differences in BP. TG and HDL-C values Δ more favorably with low-CHO diets. After six months: • TG, weighted mean difference, -22.1mg per dL (-0.25mmol per L); 95% CI: -38.1, -5.3mg per dL (-0.43 to -0.06mmol per L) • HDL-C, weighted mean difference, 4.6mg per dL (0.12mmol per L); 95% CI: 1.5 to 8.1mg per dL (0.04 to 0.21mmol per L). For TC and LDL-C values Δ more favorably with low-fat diets. After six months: • LDL-C, weighted mean difference, 5.4mg per dL (0.14mmol per L); 95% CI: 1.2 to 10.1mg per dL (0.03 to 0.26mmol per L).
Rankin and Turpyn 2007 Study Design: Randomized Controlled Trial Class: A Rating:	N=29 women. Age: 32 to 45 years. BMI: 32kg/m2. Attrition: 9%.	Subjects were randomly assigned to one of two self-selected diets, either a low-CHO diet or a high-CHO diet for four weeks. Weekly group sessions and four-day food records were used to assess compliance with the study protocol.	Not applicable.	Low-CHO: 10%, 60%, 30%. High-CHO: 60%, 20% to 25%, 15% to 20%.	Both groups ↓ weight, but the low-CHO diet group ↓ (-3.8±1.2kg) more weight than the high-CHO diet group (-2.6±1.7kg) (P=0.04).	Not applicable.	Not applicable; study <six months.
Sacks FM, Bray GA et al, 2009 Study Design: Randomized clinical trial Class: A Rating:	N=645 subjects (397 women; 248 men) Age: 52 years. BMI: 33kg/m2. Attrition at two years: 20%.	Subjects were randomly assigned to one of four energy-reduced (-750kcal per day) diet groups: • Low-fat, average PRO • Low-fat, high PRO • High-fat, average PRO • High-fat, high-PRO. Subjects were offered group and individual counseling session for two years and daily web-based food records were used to assess compliance with the study protocol. Weight measurements were taken at baseline, six months and two years.	Not applicable.	Low-fat, average PRO: 65%, 20%, 15%. Low-fat, high-PRO: 55%, 20%, 25%. High-fat, average PRO: 45%, 40%, 15%. High-fat, high-PRO: 35%, 40%, 25%.	At six months, all groups ↓ a similar amount of weight (6kg or ~7% of initial weight), but began to regain weight after 12 months.	At two years, weight ↓ remained similar in those assigned to the 15% PRO and 25% PRO diets (-3.0 and -3.6kg, respectively); in those assigned to the 20% and 40% fat diets (-3.3kg for both groups); and in those assigned to the 65% and 35% CHO diets (-2.9 and -3.4kg, respectively) (P>0.20 for all comparisons).	All diets reduced CVD and diabetes risk factors at six months and two years. The low-fat diets and the highest CHO diet ↓ LDL-C levels more than the high-fat diets and the lowest-CHO diet (P=0.0001). The lowest-CHO diet ↑ HDL-C level more than the highest-CHO diet (P=0.02). All the diets ↓ TG levels and BP similarly, and all diets except the highest-CHO diet, ↓ fasting serum insulin levels (P=0.07).
Shai et al 2008 Study Design: Radomized Controlled Trial Class: A Rating:	N=272 subjects (86% males). Age: 52 years. BMI: 31kg/m2. Attrition at two years: 16%.	Subjects were randomly assigned to either: • Low-fat diet • Mediterranean diet • Low-CHO diet. The first six months of the trial was the weight ↓ phase, followed by 18 months of weight maintenance. Adherence to the study diets was assessed using a FFQ. Weight was assessed monthly, but only 24-month data is reported.	Not applicable.	Low-CHO: 40%, 38%, 22%. Mediterranean diet: 50%, 32%, 18%. Low-CHO: 40%, 38%, 22%.	Not reported in this paper.	All groups ↓ weight over the 24-month trial. • Low-CHO group ↓ -5.5±7.0kg • Mediterranean-diet group ↓ -4.6±6.0kg • Low-fat group ↓ -3.3±4.1kg. P=0.03 for the comparison between the low-fat and low-CHO groups at 24 months.	All groups ↓ BP, but between group differences were NS. HDL-C ↑ in all groups, with the low-CHO group ↑ levels more than the low-fat group (P<0.01). TG levels ↓ more in the low-CHO groups compared to the low-fat group (P=0.03) and LDL-C did not Δ in any of the groups. TC:HDL-C ratio ↓ 20% in the low-CHO group and 12% in the low-fat group (P=0.01). In subjects with diabetes,

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							changes in fasting plasma glucose and insulin levels were more favorable among those assigned to the Mediterranean diet than those assigned to the low-fat diet (P<0.001).
Tay et al 2008 Study Design: Randomized Clinical Trial Class: A Rating:	N=88 subjects completed the trial. Age: 18 to 65 years. BMI: 34kg/m2. N=45 subjects in the VLCHF group; N=43 in the HCLF group. Attrition: 19%.	Subjects were randomly assigned to either a very-low-CHO, high-fat diet (VLCHF) and a high-CHO, low-fat diet (HCLF). Participants were provided with some food to enhance compliance with the dietary interventions and three-day food records were kept every two weeks to assess dietary intake.	Not applicable.	VLCHF: 4%, 61%, 35%. HCLF: 46%, 30%, 24%.	Weight loss was similar in both groups, as VLCHF subjects ↓-11.9±6.3kg and HCLF subjects ↓ -10.1±5.7kg.	Not applicable.	BP, CRP, fasting glucose and insulin ↓ similarly in both diet groups. The VLCHF diet produced greater ↓ in TG (P=0.01) and ↑ in HDL-C (P=0.002), while the HCLF diet produced a greater ↓ in LDL-C (P<0.001).
Viguerie N, Vidal H et al, 2005 Study Design: Randomized Controlled Trial Class: A Rating:	N=50 women. Age: 21 to 49 years. BMI: 36kg/m2. N=25 in high-fat, low-CHO group; N=25 in low-fat, high-CHO group.	Subjects were randomly assigned to one of two similarly energy-restricted diets for 10-weeks: • High-fat, low-CHO diet • Low-fat, high-CHO diet.	Not applicable.	High-fat: 40%, 42%, 18%. Low-fat: 59%, 24%, 17%.	Weight ↓ significantly on both the high-fat (99.4±2.7kg to 92.7±2.8kg; P<0.0001) and low-fat (100.3±3.9kg to 93.5±4.1kg; P<0.0001) diets. Fat mass ↓ significantly on both the high-fat (43.5±2.0kg to 37.7±2.0kg; P<0.0001) and low-fat (43.7±2.7kg to 37.2±2.6kg; P<0.0001) diets. However, there were no differences in the effects on weight and fat mass between the two diet types.	Not applicable.	Not applicable.
Volek JS, Phinney SD et al, 2009 Study Design: Randomized Controlled Trial Class: A Rating:	N=40 adults. Age: 18 to 55 years. BMI: 33kg/m2. N=20 in CRD group; N=20 in LFD group.	Subjects received weekly counseling throughout the study and seven-day food records were collected at weeks one, six and 12 to assess compliance.	Not applicable.	CRD: 12%, 59%, 28%. LFD: 56%, 24%, 20%.	Weight ↓ in the CRD groups was significantly greater (96.5±13.7kg to 86.4±12.0kg) than in the LFD group (94.4±15.2kg to 89.2±13.9kg) (P<0.0001). Whole body fat mass ↓ significantly more in CRD subjects (38.7±7.7kg to 33.1±7.9) than in LFD subjects (37.1±10.0kg to 33.4±9.4kg) (P<0.01).	Not applicable.	Not applicable; study <six months.
Wal JS, McBurney MI et al, 2007 Study Design: Randomized Controlled Trial Class: A Rating:	N=125 subjects (25 men; 112 women). Age: 50 years. BMI: 35kg/m2. N=44 in Control group; N=41 in Low CHO group and N=40 in the Moderate CHO group. Attrition: 9%.	Control: Instructed to follow normal daily routines. Low CHO: • Breakfast: Atkins Shake or Breakfast Bar, fruit or yogurt • Lunch: Atkins-consistent lunch • Dinner: Atkins shake/bar, fruit, salad with fat-free dressing. Moderate CHO: • Breakfast/Lunch: Special K Low-CHO cereal with low-fat milk • Dinner: Fruits, salad with fat-free dressing and a low-fat, low-calorie meal.	Not applicable.	Not applicable.	Weight ↓ significantly more in the Low-CHO (-2.94±2.25kg) and Moderate-CHO (-2.6±2.39kg) groups, compared to the Control group (-0.61±1.33kg) (P<0.0001). Mean weight ↓ did not differ between Low- and Moderate-CHO groups.	Not applicable.	Not applicable; study <six months.
White AM, Johnston SC et al, 2007 Study Design: Randomized Controlled Trial Class: A Rating:	N=19 subjects (four men; 15 women). Mean age: 38 years. Mean BMI: 34kg/m2. N=9 in ketogenic group; N=10 in non-ketogenic group. Attrition: 10%.	Participants were provided with all foods consumed during the two-week study period. Energy intake was controlled to provide ~70% of that needed for weight maintenance.	Not applicable.	Ketogenic: 5%, 65%, 30%. Non-ketogenic: 40%, 30%, 30%.	Both groups ↓ weight during the two-week trial, but there were no differences between the groups. The ketogenic diet results in weight ↓ from 96.9±5.6kg at baseline to 92.9±5.6kg at two weeks. The non-ketogenic results in weight ↓ from 100.3±6.1kg at baseline to 96.3±5.8 at two weeks.	Not applicable.	Not applicable; study < six months.

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Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

Arvidsson E, Viguerie N, Andersson I, Verdich C, Langin D, Arner P. Effects of different hypocaloric diets on protein secretion from adipose tissue of obese women. *Diabetes*. 2004 Aug;53(8):1966-71.

Avenell A, Brown TJ, McGee MA, Campbell MK, Grant AM, Broom J, Jung RT, Smith WC. What are the long-term benefits of weight reducing diets in adults? A systematic review of randomized controlled trials. *J Hum Nutr Diet*. 2004 Aug;17(4):317-35.

Benassi-Evans B, Clifton PM, Noakes M, Keogh JB, Fenech M. High protein-high red meat versus high carbohydrate weight loss diets do not differ in effect on genome stability and cell death in lymphocytes of overweight men. *Mutagenesis*. 2009;24(3):271-277.

Bopp MJ, Houston DK, Lenchik L, Easter L, Kritchevsky SB, Nicklas BJ. Lean mass loss is associated with low protein intake during dietary-induced weight loss in postmenopausal women. *J Am Diet Assoc*. 2008;108:1216-1220.

Buscemi S, Verga S, Tranchina MR, Cottone S, Cerasola G. Effects of hypocaloric very-low-carbohydrate diet vs. Mediterranean diet on endothelial function in obese women. *Eur J Clin Invest*. 2009 May; 39 (5): 339-347.

Capel F, Viguerie N, Vega N, Dejean S, Arner P, Klimcakova E, Martinez JA, Saris WH, Holst C, Taylor M, Oppert JM, Sørensen TI, Clément K, Vidal H, Langin D. Contribution of energy restriction and macronutrient composition to changes in adipose tissue gene expression during dietary weight-loss programs in obese women. *J Clin Endocrinol Metab*. 2008 Nov;93(11):4315-22. Epub 2008 Sep 9.

de Luis DA, Sagrado MG, Conde R, Aller R, Izaola O. The effects of two different hypocaloric diets on glucagon-like peptide 1 in obese adults, relation with insulin response after weight loss. *J Diabetes Complications*. 2009 Jul-Aug; 23(4): 239-243. Epub 2008 Apr 16.

Frisch S, Zittermann A, Berthold HK, Götting C, Kuhn J, Kleesiek K, Stehle P, Körtke H. A randomized controlled trial on the efficacy of carbohydrate-reduced or fat-reduced diets in patients attending a telemedically guided weight loss program. *Cardiovasc Diabetol*. 2009 Jul 18;8:36.

Gordon MM, Bopp MJ, Easter L, Miller GD, Lyles MF, Houston DK, Nicklas BJ, Kritchevsky SB. Effects of dietary protein on the composition of weight loss in post-menopausal women. *J Nutr Health Aging*. 2008 Oct;12(8):505-9.

Halton TL, Hu FB. The effects of high protein diets on thermogenesis, satiety and weight loss: a critical review. *J Am Coll Nutr*. 2004;23(5):373-85.

Halyburton AK, Brinkworth GD, Wilson CJ, Noakes M, Buckley JD, Keogh JB, Clifton PM. Low- and high-carbohydrate weight-loss diets have similar effects on mood but not cognitive performance. *Am J Clin Nutr*. 2007 Sep;86(3):580-7.

Hession M, Rolland C, Kulkarni U, Wise A, Broom J. Systematic review of randomized controlled trials of low-carbohydrate vs. low-fat/low-calorie diets in the management of obesity and its comorbidities. *Obes Rev*. 2009 Jan;10(1):36-50.

Jenkins DJA, Wong JMW, Kendall CWC, Esfahani A, Ng VWY, Leong TCK, Faulkner DA, Vidgen E, Greaves KA, Paul G, Singer W. The effect of a plant-based low-carbohydrate ("Eco-Atkins") diet on body weight and blood lipid concentrations in hyperlipidemic subjects. *Arch Intern Med*. 2009;169(11):1046-1054.

Johnston CS, Tjonn SL, Swan PD, White A, Hutchins H, Sears B. Ketogenic low-carbohydrate diets have no metabolic advantage over nonketogenic low-carbohydrate diets. *Am J Clin Nutr*. 2006 May;83(5):1055-61.

Johnstone AM, Horgan GW, Murison SD, Bremner DM, Lobley GE. Effects of a high-protein ketogenic diet on hunger, appetite, and weight loss in obese men feeding ad libitum. *Am J Clin Nutr*. 2008 Jan;87(1):44-55.

Keogh JB, Brinkworth GD, Noakes M, Belobrajdic DP, Buckley JD, Clifton PM. Effects of weight loss from a very-low-carbohydrate diet on endothelial function and markers of cardiovascular disease risk in subjects with abdominal obesity. *Am J Clin Nutr*. 2008 Mar;87(3):567-76.

Krieger JW, Sitren HS, Daniels MJ, Langkamp-Henken B. Effects of variation in protein and carbohydrate intake on body mass and composition during energy restriction: a meta-regression. *Am J Clin Nutr*. 2006; 83(2):260-274.

Leidy HL, Carnell NS, Mattes RD, Campbell WW. Higher protein intake preserves lean mass and satiety with weight loss in pre-obese and obese women. *Obesity (Silver Spring)* 2007;15(2):421-429.

Lim SS, Noakes M, Keogh JB, Clifton PM. Long-term effects of a low carbohydrate, low fat or high unsaturated fat diet compared to a no-intervention control. *Nutr Metab Cardiovasc Dis*. 2009 Aug 17.

López-Fontana CM, Sánchez-Villegas A, Martínez-Gonzalez MA, Martinez JA. Daily physical activity and macronutrient distribution of low-calorie diets jointly affect body fat reduction in obese women. *Appl Physiol Nutr Metab*. 2009 Aug; 34(4): 595-602.

Mahon AK, Flynn MG, Stewart LK, McFarlin BK, Iglay HB, Mattes RD, Lyle RM, Considine RV, Campbell WW. Protein intake during energy restriction: effects on body composition and markers of metabolic and cardiovascular health in postmenopausal women. *J Am Coll Nutr*. 2007 Apr; 26 (2): 182-189.

McAuley KA, Hopkins CM, Smith KJ, McLay RT, Williams SM, Taylor RW, Mann JI. Comparison of high-fat and high-protein diets with a high-carbohydrate diet in insulin-resistant obese women. *Diabetologia*. 2005 Jan;48(1):8-16. Epub 2004 Dec 23. Erratum in: *Diabetologia*. 2005 May;48(5):1033.

McLaughlin T, Carter S, Lamendola C, Abbasi F, Yee G, Schaaf P, Basina M, Reaven G. Effects of moderate variations in macronutrient composition on weight loss and reduction in cardiovascular disease risk in obese, insulin-resistant adults. *Am J Clin Nutr*. 2006 Oct;84(4):813-21.

McMillan-Price J, Petocz P, Atkinson F, O'Neill K, Samman S, Steinbeck K, Caterson I, Brand-Miller J. Comparison of 4 diets of varying glycemic load on weight loss and cardiovascular risk reduction in overweight and obese young adults: a randomized controlled trial. *Arch Intern Med*. 2006 Jul 24;166(14):1466-75.

Miller LE, Volpe JJ, Coleman-Kelly MD, Gwazdauskas FC, Nickols-Richardson SM. Anthropometric and leptin changes in women following different aproaches to weight loss. *Obesity (Silver Spring)* 2009;17:199-201.

Nickols-Richardson SM, Coleman MD, Volpe JJ, Hosig KW. Perceived hunger is lower and weight loss is greater in overweight premenopausal women consuming a low-carbohydrate/high-protein vs high-carbohydrate/low-fat diet. J Am Diet Assoc 2005; 105: 1433-1437.

Noakes M, Foster PR, Keogh JB, James AP, Mamo JC, Clifton PM. Comparison of isocaloric very low carbohydrate/high saturated fat and high carbohydrate/low saturated fat diets on body composition and cardiovascular risk. *Nutr Metab* (Lond). 2006 Jan 11; 3:7.

Nordmann AJ, Nordmann A, Briel M, Keller U, Yancy WS Jr, Brehm BJ, Bucher HC. Effects of low-carbohydrate vs low-fat diets on weight loss and cardiovascular risk factors: a meta-analysis of randomized controlled trials. *Arch Intern Med*. 2006 Feb 13;166(3):285-93.

Rankin JW, Turpyn AD. Low carbohydrate, high fat diet increases C-reactive protein during weight loss. *J Am Coll Nutr*. 2007 Apr;26(2):163-9.

Sacks FM, Bray GA, Carey VJ, Smith SR, Ryan DH, Anton SD, McManus K, Champagne CM, Bishop LM, Laranjo N, Leboff MS, Rood JC, de Jonge L, Greenway FL, Loria CM, Obarzanek E, Williamson DA. Comparison of weight-loss diets with different compositions of fat, protein, and carbohydrates. *N Engl J Med*. 2009; 360 (9): 859-873.

Shai I, Schwarzfuchs D, Henkin Y, Shahar DR, Witkow S, Greenberg I, Golan R, Fraser D, Bolotin A, Vardi H, Tangi-Rozental O, Zuk-Ramot R, Sarusi B, Brickner D, Schwartz Z, Sheiner E, Marko R, Katorza E, Thiery J, Fiedler GM, Blüher M, Stumvoll M, Stampfer MJ; Dietary Intervention Randomized Controlled Trial (DIRECT) Group. Weight loss with a low-carbohydrate, Mediterranean, or low-fat diet. *N Engl J Med*. 2008 Jul 17;359(3):229-41.

Tay J, Brinkworth GD, Noakes M, Keogh J, Clifton PM. Metabolic effects of weight loss on a very-low-carbohydrate diet compared with an isocaloric high-carbohydrate diet in abdominally obese subjects. *J Am Coll Cardiol*. 2008;51(1):59-67.

Viguerie N, Vidal H, Arner P, Holst C, Verdich C, Avizou S, Astrup A, Saris WH, Macdonald IA, Klimcakova E, Clément K, Martinez A, Hoffstedt J, Sørensen TI, Langin D; Nutrient-Gene Interactions in Human Obesity--Implications for Dietary Guideline (NUGENOB) project. Adipose tissue gene expression in obese subjects during low-fat and high-fat hypocaloric diets. *Diabetologia*. 2005 Jan; 48 (1): 123-131.

Volek JS, Phinney SD, Forsythe CE, Quann EE, Wood RJ, Puglisi MJ, Kraemer WJ, Bibus DM, Fernandez ML, Feinman RD. Carbohydrate restriction has a more favorable impact on the metabolic syndrome than a low fat diet. *Lipids*. 2009 Apr; 44 (4): 297-309.

Wal JS, McBurney MI, Moellering N, Marth J, Dhurandhar NV. Moderate-carbohydrate low-fat versus low-carbohydrate high-fat meal replacements for weight loss. *Int J Food Sci Nutr*. 2007 Jun; 58(4): 321-329.

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White AM, Johnston CS, Swan PD, Tjonn SL, Sears B. Blood ketones are directly related to fatigue and perceived effort during exercise in overweight adults adhering to low-carbohydrate diets for weight loss: A pilot study. *J Am Diet Assoc.* 2007 Oct; 107 (10): 1,792-1,796.

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